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Moreover $g_i^{(n)}$ is dominated by $\frac{Ar_i}{1-S_0} T^n$. Therefore equations (16) have the essential properties assumed to hold for (1), and their solution converges for $|\tau|$ sufficiently small.

It is easy to imagine a physical problem which satisfies the conditions of this theory. For example, suppose the number of mutually gravitating bodies in the universe whose masses are bounded from zero is infinite. If beyond a finite number of them (which may be arbitrarily great) their initial distances from one another increase, as the number of bodies increases, with sufficient rapidity, it is easy to show that all the hypotheses are satisfied. In this case there is a rigorous, though limited, solution of the problem of infinitely many bodies moving subject to their mutual attractions.

SEX RATIO IN PIGEONS, TOGETHER WITH OBSERVATIONS ON THE LAYING, INCUBATION AND HATCHING OF THE EGGS

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The conclusions¹ here presented are the results of a study of the records which have accumulated from 1907 to 1914 in connection with investigations of inheritance in pigeons begun at the Rhode Island Agricultural Experiment Station and later continued at the Experiment Station at Madison, Wisconsin. It is impossible in a brief space to present the data upon which the conclusions are based; for these the reader is referred to the complete report. Furthermore, although the conclusions are here presented somewhat dogmatically and as if of general application, and while we believe that they will probably be found in the main to apply generally to domestic pigeons, they are nevertheless based almost entirely on the data of the experiments mentioned and there is, therefore, no positive assurance that the results would be the same with other stock or under different conditions. The number of data obtained were, however, very considerable for pigeons, and it is felt they accordingly furnish a good foundation for the conclusions drawn.

It is commonly believed by pigeon breeders and others that from the two eggs of a clutch a pair of offspring, that is a male and a female, are produced either invariably, or at least in a great majority of instances. Furthermore, it is maintained that of this pair the male hatches from the egg which is laid first, while the egg laid later produces the female. The

breeder has also found it difficult to explain the apparent excess of males which he commonly finds in the birds saved for breeding stock. The results here presented throw conclusive light on these and on other similar questions.

Sex ratio.—The normal ratio of the sexes of pigeons hatched is 105 males to 100 females.

Death rate.—The death rate of squabs is especially high for the first two or three days after hatching, and at about 10 to 15 days of age.

Differential mortality.—(1) When the two squabs from the same clutch of eggs are of distinctly different size before the banding age (10 to 15 days) the larger squab is more often a male than a female. (2) The death rate for the two sexes in bisexual broods is essentially equal. (3) There is no marked tendency for one sex to be weaker than the other in bisexual broods, and there is only a slight indication that more males than females from such broods survive to adult life—placed at 6 months. (4) A consideration of the ratio of males to females in each of the age groups defined² does not indicate a high relative mortality of females in the ages preceding the adult stage. (5) There is a high mortality of both sexes during the first two or three years of their adult life, and this is especially high in the females between the ages of one and two years. (6) The higher mortality of females at early adult ages, together with the higher proportion of males hatched (105:100), may be in large part responsible for the prevailing notion of a considerable excess of male pigeons in adult populations and seems to furnish real substantiation for this notion. The fact that males are generally more easily recognized than females probably adds to this impression.

Ratio of bisexual to unisexual broods.—(1) The number of unisexual broods, in which the squabs are either both male or both female, somewhat exceeds in our records the bisexual broods (one squab of each sex), but the odds against the numbers obtained representing a potential equality are very slight. These facts are directly contradictory to the commonly accepted statement that the two eggs usually produce a male and a female squab. (2) Considering only the unisexual broods, the number of 'both males' to 'both females' is practically equal.

Sex with respect to order of laying.—A comparison of the numbers of each sex hatched from first eggs and from second eggs respectively, shows no tendency for the former to produce exclusively males and the latter females but, as a matter of fact, more males than females are hatched from both.

Time of laying.—(1) The mean time of laying of the first egg is about 5 p.m., and of the second egg about one o'clock of the afternoon of the

second day following. (2) The mean interval between the laying of the two eggs is practically 44 hours. (3) The mean time between the laying of the first and second eggs decreases progressively in the months from February to July inclusive. (4) There is a very sensible positive correlation (0.38 ± 0.057) between the time of laying of the first and of the second egg. The equation of the regression straight line is $y = -0.48 + 0.378x$, where x is the time p.m. of laying of the first egg, and y that of the second. This enables one to calculate the most probable time of laying of the second egg when the time the first was laid is known.

Time of hatching.—(1) The mean time of hatching of the first egg is 16.5 days after the laying of the second. (2) The mean time of hatching of the second egg is 17 days after it is laid. (3) On the average, therefore, the time from laying to hatching of the first egg is nearly a day and a half longer than it is for the second egg. This is probably to be accounted for by the fact that the first egg receives very little incubation until the second is laid. (4) There is a high correlation between the times of hatching of the two eggs of a clutch.

Control of sex.—So far as the data obtained go, they appear to indicate that sex in pigeons is determined according to the laws of chance.

Time of sitting.—(1) In case the eggs do not hatch they are seldom abandoned at the end of the normal period of incubation, but the birds continue to sit on them for a time longer. (2) The length of time they will continue to incubate the eggs varies, but averages practically six days beyond the normal period, making the mean total time of incubation, when the eggs do not hatch, 23 days after the laying of the second egg. (3) This continuance of incubation beyond the normal time under such circumstances constitutes a 'factor of safety' in the incubating instinct. (4) A pair of Mourning Doves continued to sit on substituted eggs for four days after their own had hatched in an incubator, thus disproving Raspail's assertion that wild birds have an 'exact notion of the time required for the eggs to hatch.'

¹ Summary of the results of a report bearing the same title and published as *Bulletin No. 162 of the Rhode Island Agricultural Experiment Station*.

² GROUP A. *Hatching period.* Embryos which were fully developed but which failed to hatch ('dead in shell') and birds which died within five days after hatching.

GROUP B. *Nestling period.* Squabs dying at from 6 to 28 days, inclusive.

GROUP C. *Immature or juvenile period.* Squabs living over 28 days but dying before six months of age.

GROUP D. *Adult period.* All birds living to the age of six months or more.